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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT II, MECHANICAL TRANSMISSIONS.

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THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF MECHANICAL TRANSMISSIONS USED ON DIESEL POWERED VEHICLES. TOPICS ARE (1) PURPOSE OF TRANSMISSIONS, (2) RATIO DIFFERENCE, (3) CONSTANT MESH TRANSMISSIONS, (4) FOUR-SPEED TRUCK TRANSMISSION POWER FLOW, AND (5) TRANSMISSION TROUBLESHOOTING. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "UNDERSTANDING MECHANICAL TRANSMISSIONS" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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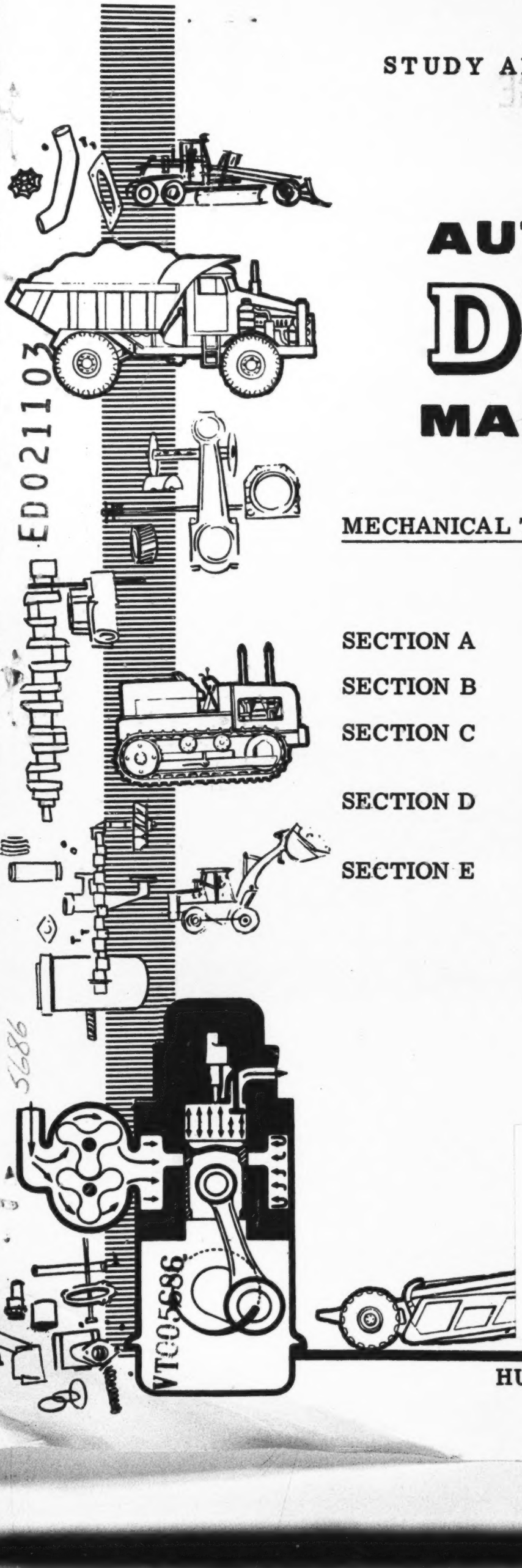


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STUDY AND READING MATERIALS

# AUTOMOTIVE DIESEL MAINTENANCE 2

## MECHANICAL TRANSMISSIONS

UNIT II

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| SECTION A | PURPOSE OF TRANSMISSIONS |
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HUMAN ENGINEERING INSTITUTE

This unit is the first in a series of nine units discussing the operation, description, troubleshooting and maintenance of transmissions. The scope of this unit will cover the standard, manually operated type of transmission and its purpose, construction and variations in design.

## SECTION A -- PURPOSE OF TRANSMISSIONS

PURPOSE -- The transmission, or gear changer, provides a means of varying the gear ratio between the engine and the rear wheels of a vehicle. Through the transmission, an engine crankshaft may be made to turn approximately four, eight, twelve, or sixteen times for each wheel revolution. In many vehicles, where very slow speeds and a great quantity of torque is required, the ratio is much greater. Also there are reverse gears which permit backing the vehicle.

LOCATION -- As we learned in the previous unit, the transmission is located to the rear of the engine, between the clutch and the drive line assembly.

## SECTION B -- RATIO DIFFERENCE

GEAR RATIOS AND TYPES OF GEARS -- What is a gear? A gear is a wheel with projections on it, called teeth. These teeth may be on the edge, on the side, or halfway between. A gear usually is fastened to a shaft. Sometimes it turns and applies a twisting force to the shaft, and sometimes the shaft turns the gear with it.

The simplest type of gear is the SPUR gear; see Figure 1. It has its teeth cut straight across the edge. For years it was almost universally used, but recently other types have become more common in the transportation field.

Fig. 1 Spur gears.

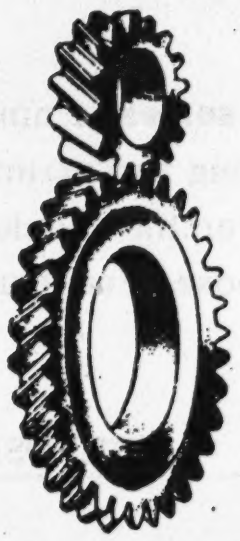


Fig. 2 Helical gears.

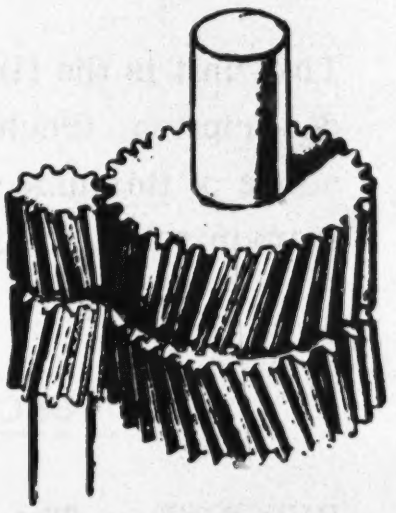


Fig. 3 Herringbone gears.

Another type is the HELICAL gear; see Figure 2. It is the same as the spur gear, except that its teeth are cut at an angle. The teeth of the gear it meshes with must of course be cut at the same angle. It usually is quieter than the ordinary spur gear, and for that reason is preferred for many uses. For the same reason, HERRINGBONE gears are used. These are like two helical gears fastened together tightly side by side, see Figure 3. Both of these gears provide greater tooth contact area, which reduces the psi load. Or conversely, both can handle larger loads for a given gear width.

When our power must turn a corner, we ordinarily use a BEVEL gear; see Figure 4. The teeth of this gear are not cut on the edge. They are cut, we might say, across the corner. The most commonly used bevel gear is the SPIRAL BEVEL GEAR, such as used in automobile and truck differentials; see Figure 5. The spiral bevel gear is somewhat like a

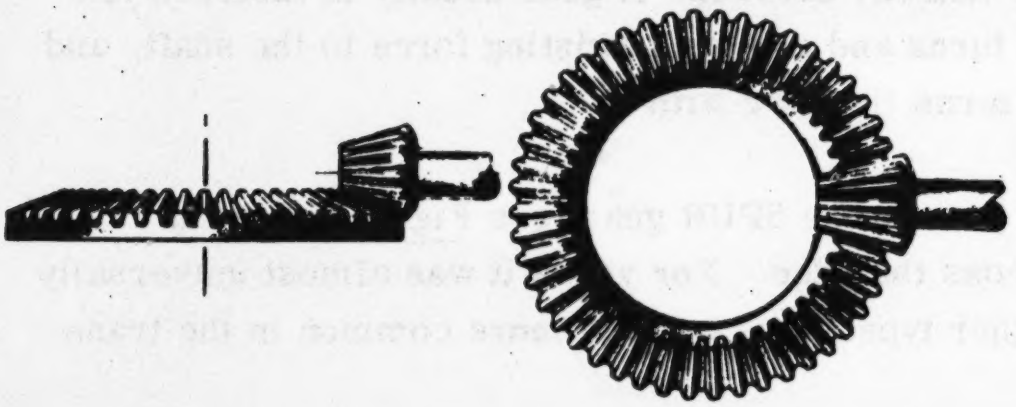


Fig. 4 Spur bevel gears.

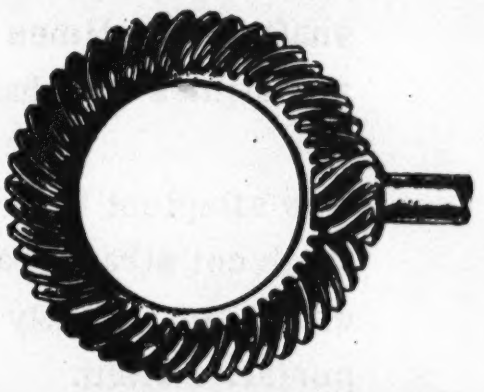


Fig. 5 Spiral bevel gears.

a helical gear, except that the teeth, in addition to being set at an angle, also are curved.

We will leave out most of the technical terms, but there is one that should be explained. PITCH DIAMETER is the diameter of the pitch circle; see Figure 6. The pitch circle is an imaginary line running through the gear teeth at a point usually a little outside the half-way point of the teeth. Hereafter, when we speak of the gear size, we will mean the pitch diameter, as that is what really determines its speed and other characteristics.

There is still another way of classifying gears: They can be external or internal. To most people the word "gear" will always bring to mind a picture of an external gear, and they will be correct a great percent of the time. But internal gears do play an important part in some mechanisms, as we will see later. An internal gear is simply a ring with teeth cut on the inside instead of the outside. Transmission planetary gears are a good example of internal gears, and will be discussed in more detail; see Figure 7.

A gear has been compared with a spinning lever. It can increase or decrease torque in exactly the same way a lever increases or decreases force. An important thing to remember is that if we have a small gear fastened onto a shaft driving a bigger gear on another shaft, the torque on

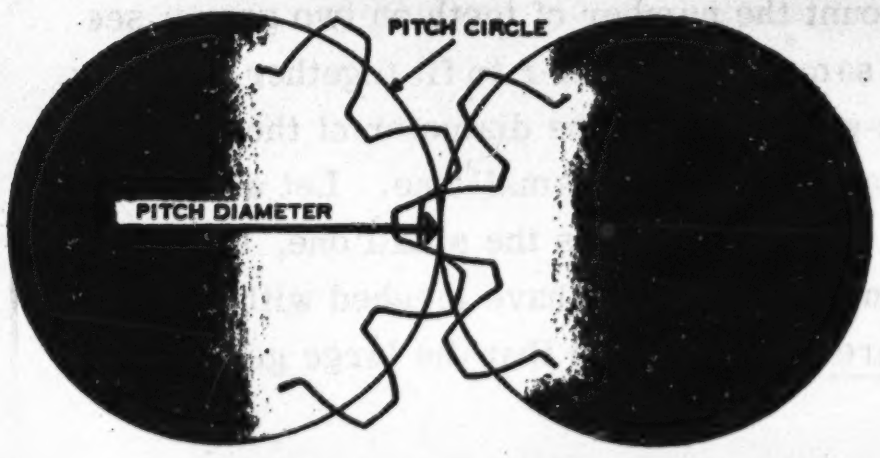



Fig. 6 Pitch diameter.

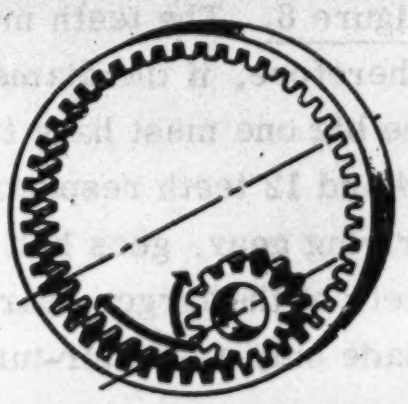


Fig. 7 Internal gear.

the second shaft will be increased. In other words, the second shaft will have more twisting force than the first shaft has.

If we have an engine driving the small gear, our system now will be able to turn something - a machine of some sort - that the engine could not turn when they were connected directly together.

The amount of torque increase depends on the relative size of the gears. If the diameter (pitch diameter) of the second gear is twice the diameter of the first gear, the torque will be doubled. If the second gear is three times as big, the torque will be three times as much, etc. But if the driving gear is twice as big as the driven gear, the output torque will be cut down to 1/2 (one-half) the input torque. With a given gear system, torque also is proportional to the relative numbers of teeth on the drive and driven gears.

In all we have discussed thus far we must remember one thing: We are not discoverers of perpetual motion nor can we claim that we get more power out of the engine because we have added some gears to the system. We are still dealing with levers, and they still follow the same rules. With levers we say that, "whatever we gain in force we lose in distance". When talking about gears and shafts we say "whatever we gain in torque we lose in speed". The two statements are not exactly the same, but we can think of them that way for the moment.

The best way to show this is to count the number of teeth on two gears; see Figure 8. The teeth must be the same size in order to fit together properly. Therefore, if the diameter of one gear is twice the diameter of the other, the big one must have twice as many teeth as the small one. Let us say 24 and 12 teeth respectively; see Figure 8 (a). As the small one, the driving gear, goes half-way around, its six teeth have meshed with six teeth of the larger gear; see Figure 8 (b). Notice that the large gear has made only a quarter-turn.

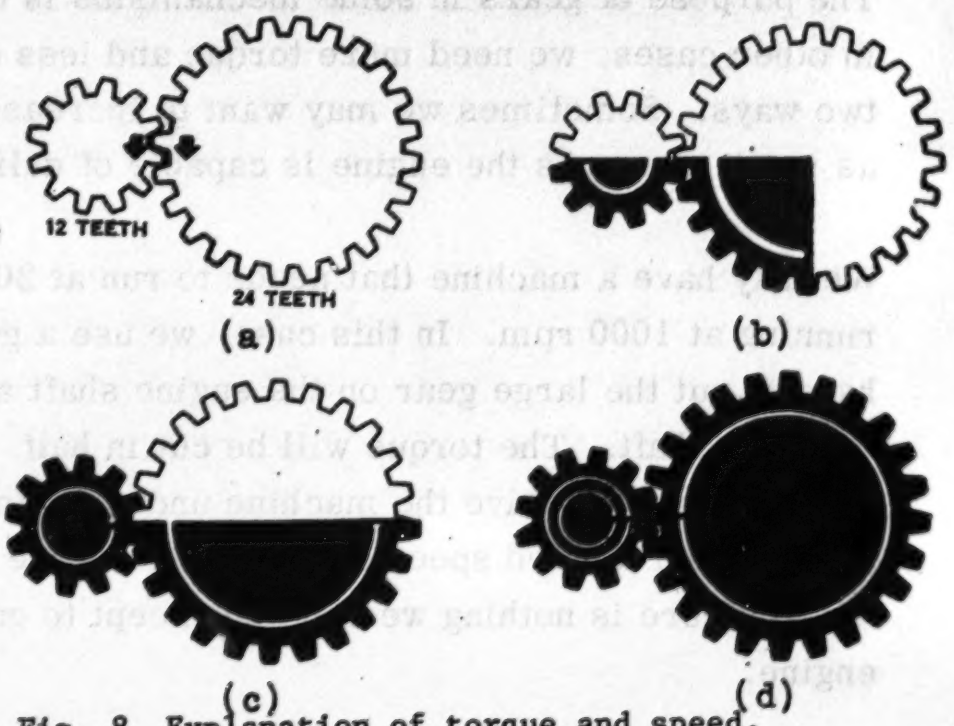



Fig. 8 Explanation of torque and speed.

As the small gear makes one revolution, the large gear only turns halfway; see Figure 8 (c). For the large gear to turn once, the small gear has to make two revolutions; see Figure 8 (d). So for every two revolutions of the small driving gear the large driven gear revolves only once. And for every 1000 revolutions of the small gear the large one has made only 500 revolutions. Therefore, if an engine driving the small gear is running at a speed of 1000 revolutions per minute (rpm) the machine driven by the large gear is turning at a speed of only 500 rpm. We have doubled the torque furnished by the engine. We have increased the twist on the second shaft so that now it can turn the machine when perhaps it could not do this previously.

We have just attempted to explain, to some degree, gear ratio: the amount of change in torque and speed. If the driving gear has 10 teeth and the driven gear has 30 teeth, it will take three revolutions for the first gear to get the second gear all the way around, through one revolution. Thus the speed of the driven gear will be one-third of the driving gear, and we know that the torque will be multiplied by three. We would say that the gear ratio is 30/10 or 3 to 1. This applies equally as well if we have an odd combination of numbers, such as 39 to 19, only it is not so easy to do the mathematics. The gear ratio would be 39/19 or a little over 2 to 1.

The gear with the greater number of teeth will always run more slowly and will deliver more (greater) torque.

The purpose of gears in some mechanisms is to act as speed reducers. In other cases, we need more torque and less speed, and we thus gain two ways. Sometimes we may want to increase the speed, but do not need as much torque as the engine is capable of delivering.

We may have a machine that needs to run at 2000 rpm, and an engine running at 1000 rpm. In this case, we use a gear ratio of 2 to 1, but we have to put the large gear on the engine shaft and the small one on the machine shaft. The torque will be cut in half. But, if the engine has enough power to drive the machine under those conditions, the machine will run at required speed of 2000 rpm. If we need more torque and more speed, there is nothing we can do, except to get more power from the engine.

What we have been saying is really the same thing as is expressed by the formula found in text books: that power equals torque times speed. The gears cannot change the power; that stays the same. Therefore, if the torque increases, the speed must decrease; if the speed goes up, the torque must go down.

In some mechanisms we have more than two gears between the input and the output. A clock or watch is a good example. Suppose we look at some multiple gear arrangements; see Figure 9. We will go back to our same two gears with 12 and 24 teeth, and add another pair of gears to the system. They are just like the first two, 12 and 24 teeth respectively, and a small gear (C) is fastened to the same shaft as the large gear (B). Now let us follow the power flow path through this gear train. The engine is connected to the top shaft and is still running at 1000 rpm. We already know what happens to the first two gears. The speed is cut in half and the torque is doubled. So our second shaft is turning only 500 rpm, which means that gear (C) is turning at that same speed.

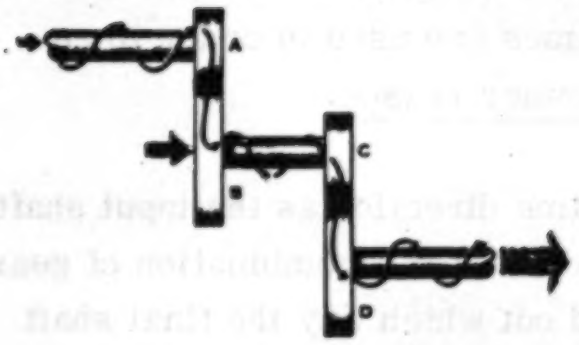



Fig. 9 Multiple gear arrangement.

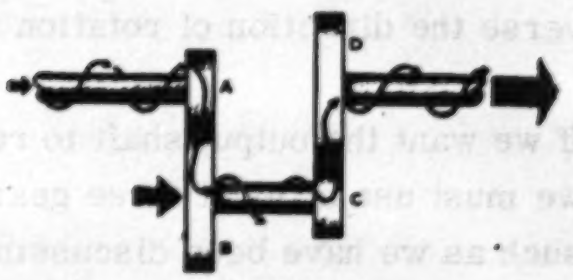



Fig. 10 Typical gear arrangement.

Now we can forget about the first two gears and consider only gears (C) and (D). We know what happens there too, because they are just the same gears, with a ratio of 2 to 1. Our speed will be reduced by one-half again, and the torque doubled once more. So our last shaft, which is driving a machine, is turning at only 250 rpm, but it is applying to the machine a torque or twist four times as much as that delivered by the engine. The overall ratio of the whole system is 4 to 1.

In a simple case such as the one just explained, we can get the same effect by using only two gears of the proper ratio. Sometimes, however, there is too great a difference for this arrangement to be efficient, and sometimes it is a matter of convenience or space saving. In actual practice, we ordinarily would not arrange the gears as we have in the example just explained. We would save space by moving the third shaft up above the second; see Figure 10. The result would be exactly the same, and we would have the added advantage that the first and third shafts would be directly in line. What we really have here now is a simplified arrangement of a conventional automobile transmission. The third shaft would extend back to the rear axle to drive the wheels.

There is another feature in using four gears here instead of two, which is sometimes an advantage. This brings up something that has not been mentioned, which has to do with direction of rotation. Looking at a pair of gears, it is easy to see that if one shaft rotates in one direction, the

other must rotate in the other direction. If one runs clockwise, the other must go counterclockwise. Gears sometimes are used in order to reverse the direction of rotation and for no other reason.

If we want the output shaft to run in the same direction as the input shaft, we must use at least three gears. Or, we can use a combination of gears such as we have been discussing. To find out which way the final shaft turns in any complicated system of gearing, one of the best procedures is to go through the whole system and figure out which way each gear turns. And do not forget the exception to the above: when an ordinary external gear is driving an internal gear, both shafts will turn in the same direction.

The purpose and location of the transmission have been mentioned before--to let us vary the speed and torque of the rear axle in relation to the speed and torque of the engine. Next, we will discuss the simple three speed conventional transmission. FIRST SPEED, or low gear (see Figure 11) is used for starting and for steep hills or heavy going in sand, mud, etc. It lets the engine run fast while the vehicle runs slowly. The engine runs at 2 1/2 to 3 times as fast as the drive shaft. The exact figure varies in different vehicles. In short, the torque of the drive shaft is increased as the speed is reduced. Thus we have a lot of twist (torque) on the rear wheels to get the vehicle started from a stand-still.

This is accomplished with four gears and three shafts. A small gear on the shaft from the clutch drives a larger gear fastened to the transmission countershaft. Another smaller gear fastened on the countershaft drives a large gear on the third shaft. The last (third) shaft goes to the drive shaft.

In the arrangement just described there is a certain speed reduction in the first two gears, and there is more reduction in the second set of gears. The countershaft is running at a speed in between the speeds of the other two shafts. The third (output) shaft is running slower (most slowly) than the other two, but with the most torque.

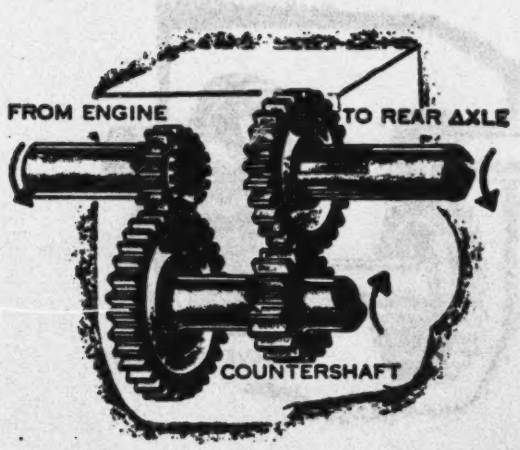



Fig. 11 First or low gear.

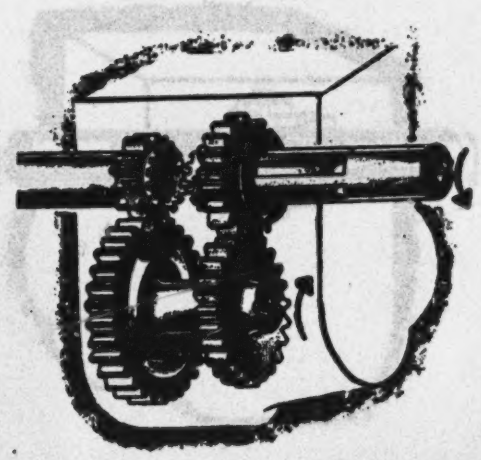


Fig. 12 Second or intermediate gear.

SECOND, or intermediate gear (see Figure 12) works in about the same way. The first two gears are the same as we used in low gear. The next pair are different. They are almost the same size, and sometimes the countershaft gear may be the larger. Thus the countershaft runs at the same speed as before, but there is little if any additional reduction from that to the third shaft. So, the wheels will run faster for the same engine speed than they did in low gear. A typical ratio in second gear is around 1 2/3 to 1. This means that the drive shaft will run at 1000 rpm when the engine is running at 1670 rpm.

THIRD, or high gear, is direct drive (see Figure 13). The transmission does not do anything. We simply connect the first (input) shaft with the (output) third shaft, and they turn together, as one. The drive (propelier) shaft turns the same speed as the engine, and delivers engine torque. In this case the ratio would be 1 to 1.

Besides the three forward speeds, there are two other combinations we can get in the transmission. There is NEUTRAL, in which the transmission shaft is disconnected from the clutch shaft, and the engine cannot drive the propeller shaft or anything beyond the transmission. The neutral position has about the same effect as disengaging the clutch.

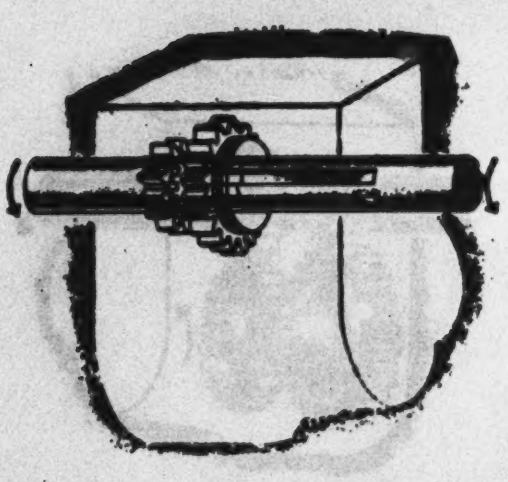


Fig. 13 Third, or high gear.

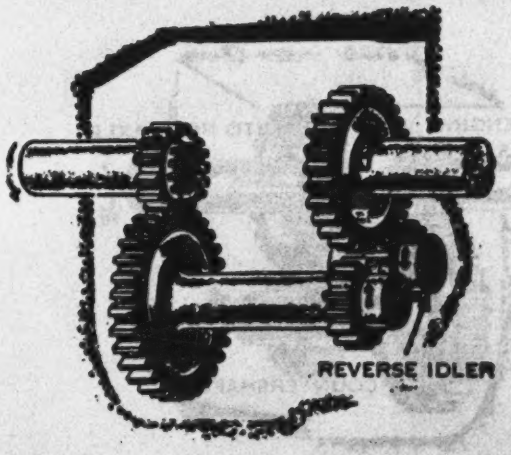



Fig. 14 Reverse gear.

Then, there is REVERSE. It is a complicated matter to make an internal combustion engine run backwards, so in most cases it is run in one direction all the time and gears are used to reverse the direction of the propeller shaft; see Figure 14. An extra gear is put in between the countershaft and the final drive shaft. It is called a reverse idler. The countershaft is driven the same way as before, it drives the reverse idler, which in turn drives a low speed gear on the final (propeller) drive shaft. The system is just like low gear that was described before except for the extra gear. The extra gear changes the direction of rotation, and it is easy to see that the final drive shaft is turning opposite to what it was in all the previous cases. The ratio in reverse is about the same as low gear, or even lower.

We have discussed the combinations in the ordinary, three speed transmission. They can be put together in various ways to make the complete transmission. Some of the first transmissions used to slide the gears back and forth on the shafts to get them into mesh and out of mesh. This was done by using a splined or grooved shaft. In this manner, a gear is fastened to the shaft as far as revolving is concerned, but it can slide along the revolving shaft to different locations.

## SECTION C -- CONSTANT MESH TRANSMISSION

The most commonly used transmission now is the constant mesh transmission. Some of the gears still slide, but some are constantly in mesh with each other and rotate all the time. The gears in a constant mesh transmission do not necessarily drive the shaft; they are free to rotate on it until they are connected to it by a clutch.

The clutch just mentioned is not a friction clutch, but is a positive clutch, more like a gear having teeth that fit into similar teeth on the gear; see Figure 15. It is called a clutch because its only job is to connect or disconnect the gear and the shaft.

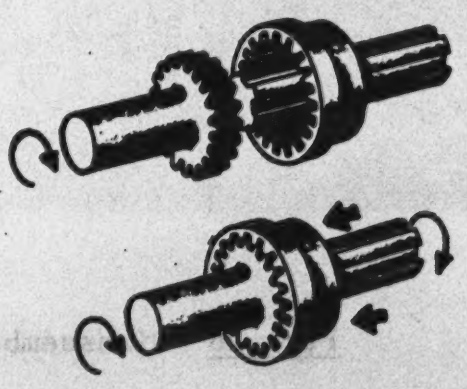


Fig. 15 Positive clutch.

To eliminate the usual transmission noise developed in the old type spur-tooth gears used in the sliding gear transmission, the manufacturers developed the constant mesh transmission, which contains helical gears. In this type of transmission certain countershaft gears are constantly in mesh with the main shaft gears. The main shaft meshing gears are arranged so that they cannot move endwise. They are supported by roller bearings so that they can rotate independently of the main shaft.

In operation, when the shift lever is moved, it moves the shifter fork which in turn moves the clutch gear. This movement engages the external teeth of the clutch gear, with the internal teeth locking the two halves together and they turn as one. The clutch gear is splined to the main shaft, and therefore, the main shaft rotates with the clutch gear; see Figure 16.

Constant-mesh gears are seldom used for all speeds. Common practice is to use such gears for the higher gears, with sliding gears for first and reverse speeds or for reverse only.

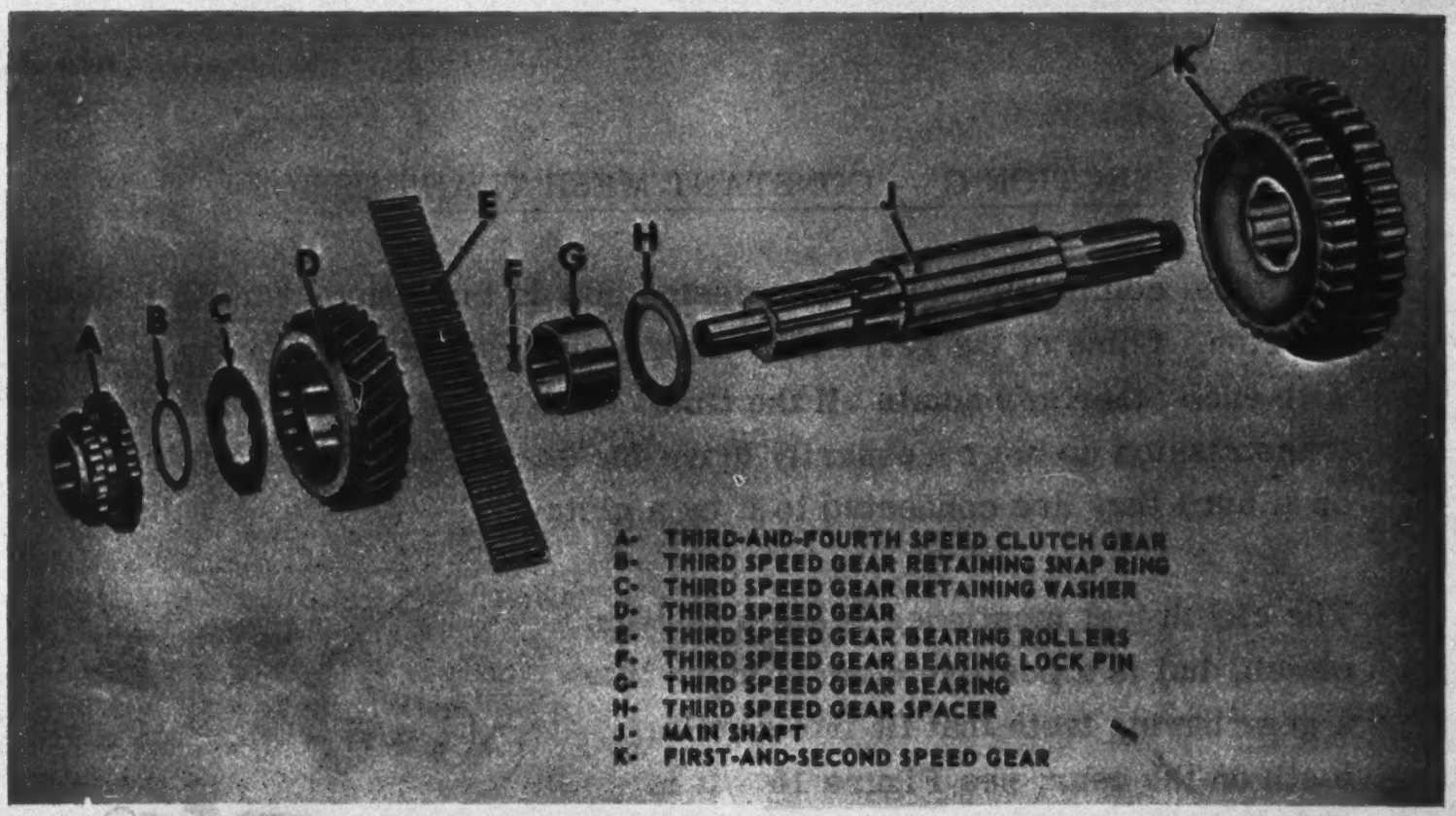



Fig. 16 Disassembled main shaft assembly.

## SECTION D -- FOUR-SPEED TRUCK TRANSMISSION POWER FLOW

The gear shift lever positions shown in Figure 17 are typical of most four-speed truck transmissions. The gear shift lever, shown at (A), (B), (C), (D), and (E) in Figure 17 changes the position of the two shifting forks, which slide on separate shafts secured to the transmission case cover. Follow the separate diagrams to learn what takes place in shifting from one speed to another. For example, as you move the top of the gear shift lever toward the forward left position, the lower arm of the lever moves in the opposite direction to shift the gears. The fulcrum of this lever is in the transmission cover.

In shifting transmission gears it is necessary to use the clutch to disengage the engine. Improper use of the clutch will cause the gears to clash, and may damage them by breaking the gear teeth. A broken tooth

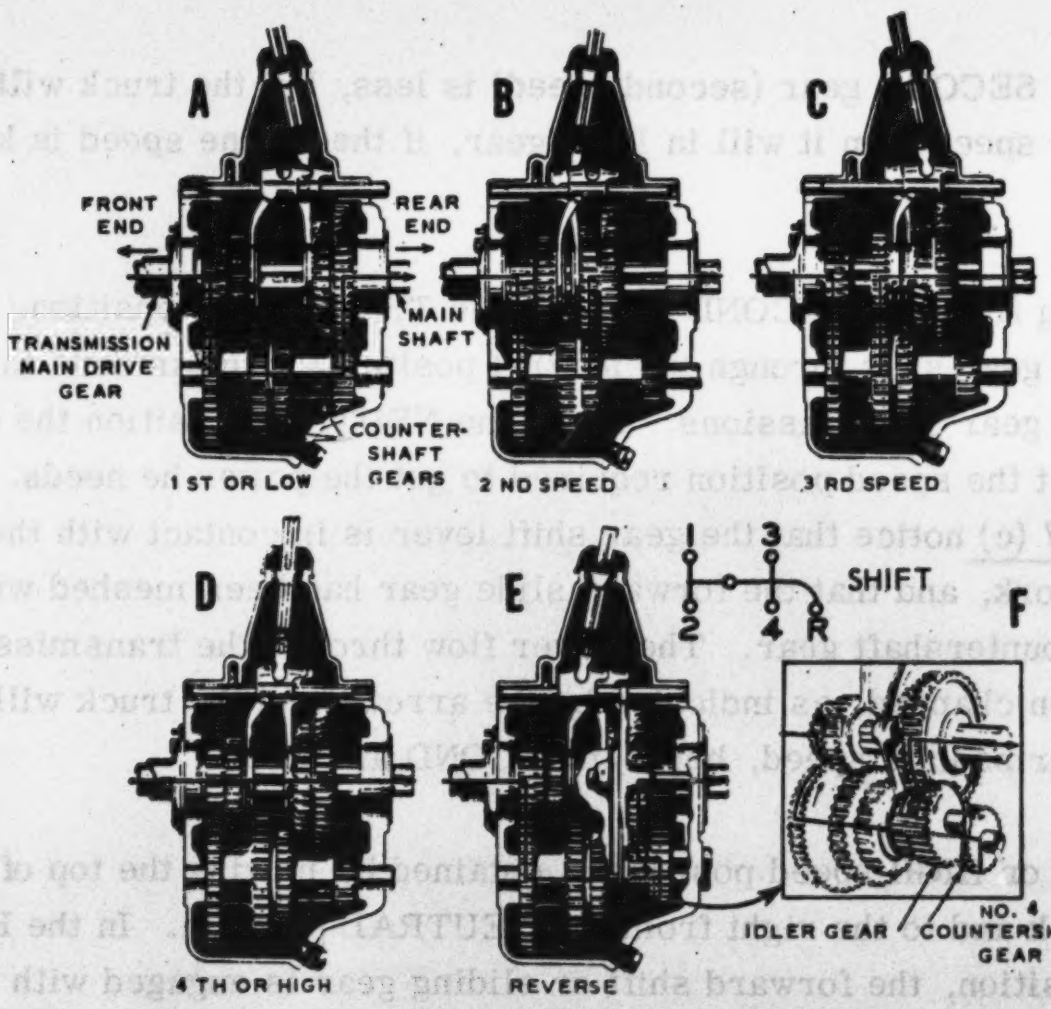



Fig. 17 Power flow through a four-speed transmission.

or piece of metal can wedge itself between two moving gears and ruin the entire transmission assembly.

When you shift from NEUTRAL to FIRST or LOW speed (see Figure 17 (a) ), the smallest countershaft gear engages with the largest sliding gear. LOW gear moves the truck at its lowest speed and maximum power. An arrow indicates the flow of power from the clutch shaft to the propeller shaft.

The SECOND speed position is obtained by moving the gear shift lever straight back from the LOW speed position. As mentioned before, you will use the clutch when shifting gears. In Figure 17 (b), the next to the smallest countershaft gear is in mesh with the second largest gear. The largest sliding gear (shift gear) has been disengaged. The flow of power has been changed as shown by the arrow. The power transmitted to the

wheels in SECOND gear (second speed) is less, but the truck will move at a greater speed than it will in LOW gear, if the engine speed is kept the same.

In shifting from the SECOND speed to the THIRD speed position, you move the gear shift through the neutral position. This is done in all selective gear transmissions. From the NEUTRAL position the driver can select the speed position required to get the power he needs. In Figure 17 (c) notice that the gear shift lever is in contact with the other shifting fork, and that the forward slide gear has been meshed with the second countershaft gear. The power flow through the transmission has again been changed, as indicated by the arrow, and the truck will move at an intermediate speed, between SECOND and HIGH.

FOURTH or HIGH speed position is obtained by moving the top of the shift lever back and to the right from the NEUTRAL position. In the HIGH speed position, the forward shift or sliding gear is engaged with the constant speed gear as shown in Figure 17 (d). The clutch shaft and the transmission shaft are now locked together and the power flow is in a straight line. In HIGH, the truck propeller shaft revolves at the same speed as the engine crankshaft, or at a 1 to 1 ratio.

You shift to REVERSE (see Figure 17 (e) (f) ) by moving the top of the gear shift lever to the far right and then to the rear. Most trucks have a trigger (interlock) arrangement at the gear shift ball to unlock the lever so that it can be moved from neutral to the far right. There will be some variation from different makes of trucks, from the position of REVERSE and the type of interlock. The lock prevents unintentional shifts to reverse. Never attempt to shift into reverse until the forward motion of the vehicle has been completely stopped.

An idler gear is used to reverse direction in a gear train. Notice how the idler gear fits into the transmission gear train. An additional shifting fork is contacted by the shift lever in the far right position. When the shift to reverse is completed, this fork moves the idling gear into mesh with the small countershaft gear and the large sliding gear at the same time. The small arrows in the inset show how the engine power flows through the transmission to move the propeller shaft and the wheels in the reverse direction.

The different combination of gears in the transmission case makes it possible to change the vehicle speed while the engine speed remains the same. It is all a matter of gear ratios. Large gears drive small gears, and small gears drive large gears.

In the truck transmission just described, the gear reduction in LOW gear is about 7 to 1 from the engine to the propeller shaft. In HIGH gear the ratio is 1 to 1, and the propeller shaft turns at the same speed as the engine. The SECOND and THIRD speed positions provide intermediate gear reductions between LOW and HIGH. The gear reduction, or gear ratio, in REVERSE is about the same as in LOW gear, and the propeller shaft makes one revolution for every seven of the engine.

In all our discussion and figures so far in this unit we have not taken friction into account at all. Friction is a variable factor and is hard to pin down. Bearings and lubrication are a very important subject, but too large to include in this unit. So, in most of the examples we show, we will assume that the mechanism has the proper bearings and is well lubricated.

In transmission systems, we use a number of anti-friction bearings. They are ball bearings, roller bearings and needle bearings. They have allowed us to do things which without them would have been difficult and complicated, if not impossible otherwise. Anti-friction bearings contribute to the efficiency and high speeds at which shafts and gears now run.

## SECTION E -- TRANSMISSION TROUBLESHOOTING

As a first step in transmission service, diagnosis of the trouble should be made to pinpoint the malfunction (trouble) in the unit. It is not always possible to determine the exact location of the trouble and the unit must be removed from the vehicle so it can be disassembled and inspected. Many times, an operator will report transmission noise, when in fact, the noise may be coming from some other component of the vehicle.

Noises that appear to come from the transmission but actually originate at some other point are many and varied. For example, an unbalanced propeller shaft, defective wheel bearings, or damaged tires may cause noises which are transmitted to the transmission. These noises have no particular or characteristic sounds that would indicate their origin; they are therefore difficult to identify.

Torsional vibration is one of the most frequent causes of noises that appear to be in the transmission, but actually originate outside of it. Included among these possible outside torsional vibrations are:

1. Propeller shaft (drive shaft) out of balance
2. Worn universal joints
3. Drive shaft center bearings loose or worn
4. Worn or pitted teeth on axle pinion and ring gear
5. Wheels out of balance
6. Worn spring pivot bearings
7. Loose frame or axle U-bolts
8. Engine cooling fan out of balance
9. Engine crankshaft, flywheel, and/or clutch out of balance
10. Tires or wheels mismatched and wobbly.

This list, along with other troubles that you have encountered in your own experience, can be used in a step-by-step guide in transmission trouble-shooting. Make sure that all possibility of outside noise has been eliminated before the transmission is removed for repair.

# DIDACTOR PLATES FOR AM 2-2D

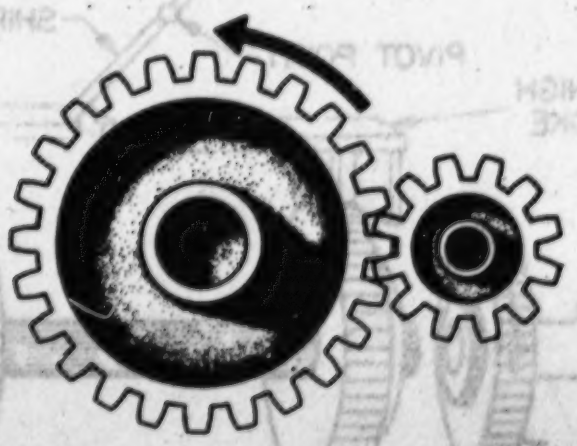


**Plate I** Two meshing gears of different types

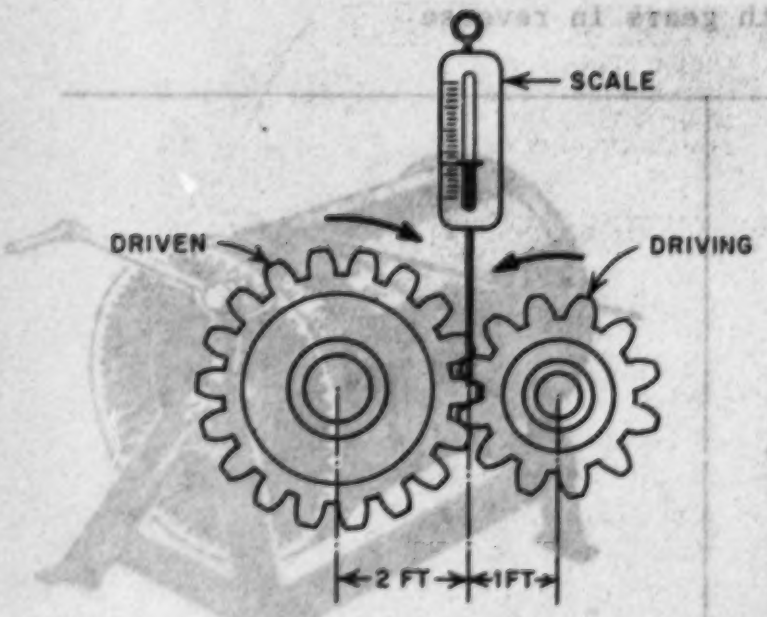



**Plate II** Torque measurement

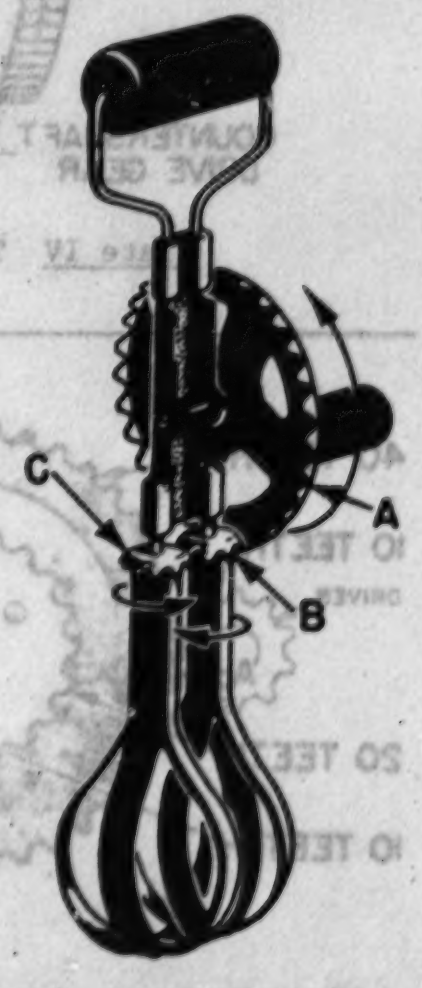



**Plate III** A simple gear arrangement

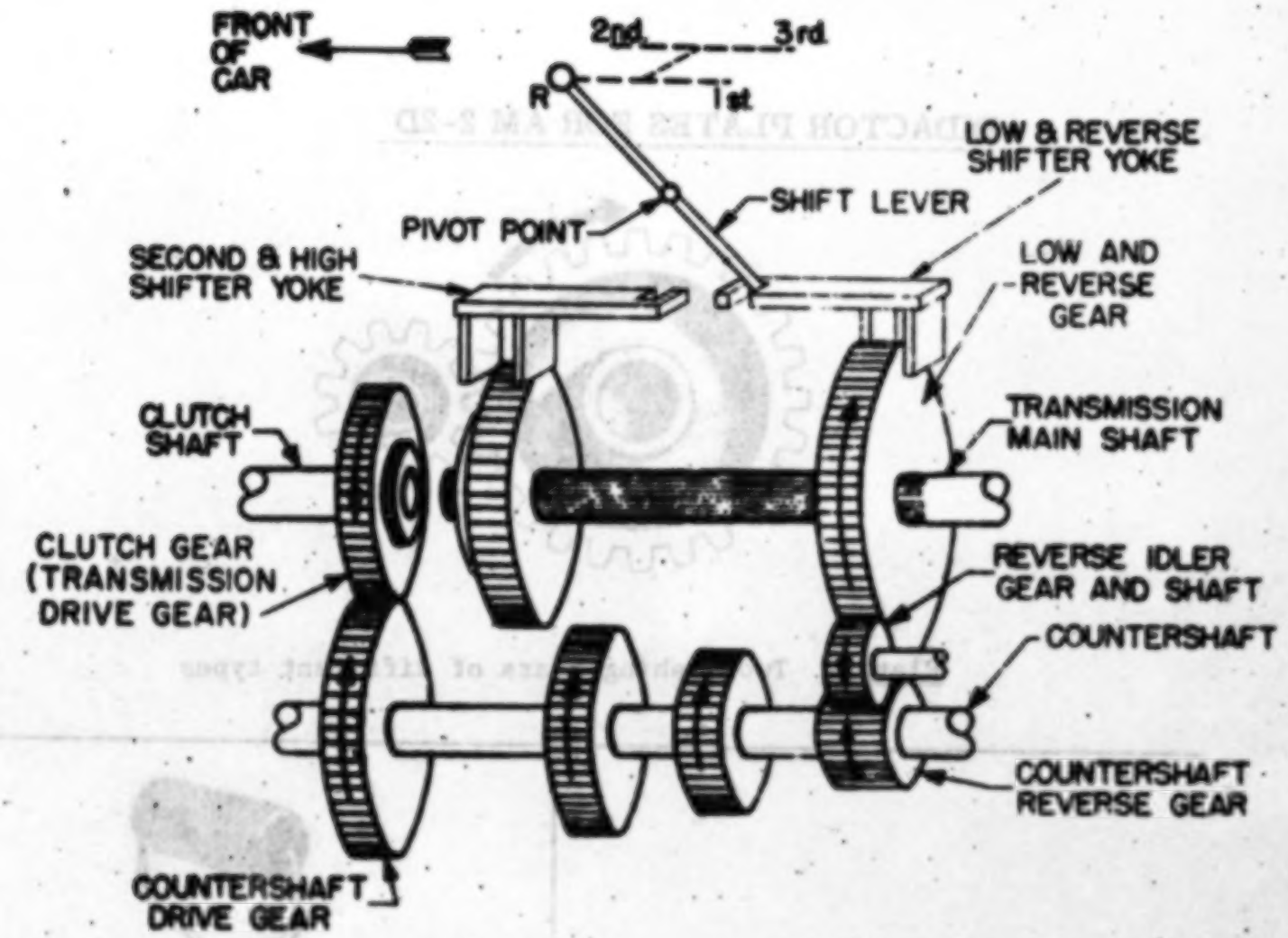



Plate IV Transmission with gears in reverse

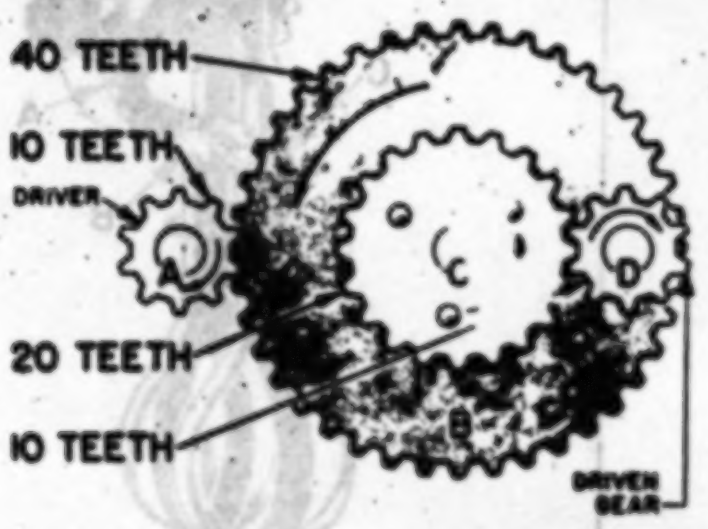



Plate V Gears changing speed of applied motion

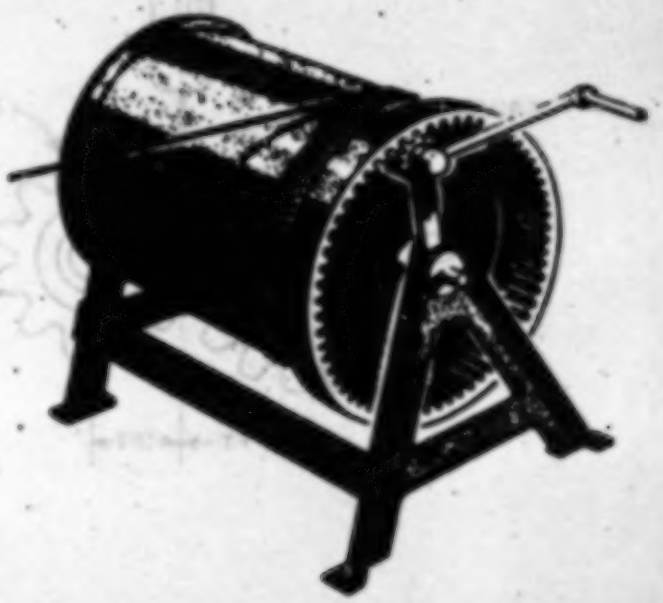


Plate VI A magnification of effort

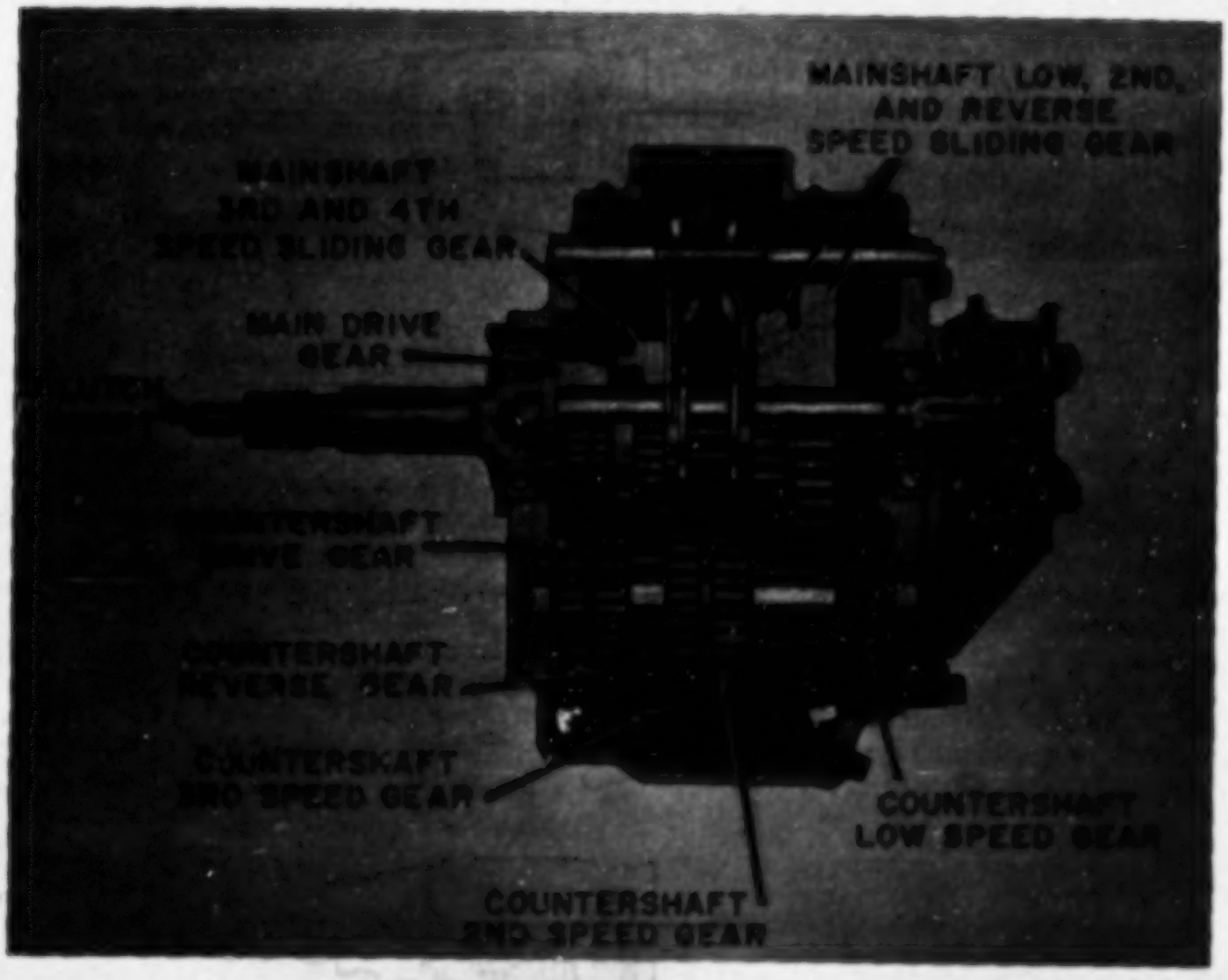

MAINSHAFT LOW, 2ND, AND REVERSE SPEED SLIDING GEAR
MAINSHAFT 3RD AND 4TH SPEED SLIDING GEAR
MAIN DRIVE GEAR
COUNTERSHAFT REVERSE GEAR
COUNTERSHAFT LOW SPEED GEAR
COUNTERSHAFT 2ND SPEED GEAR

**Plate VII** Four speed truck transmission

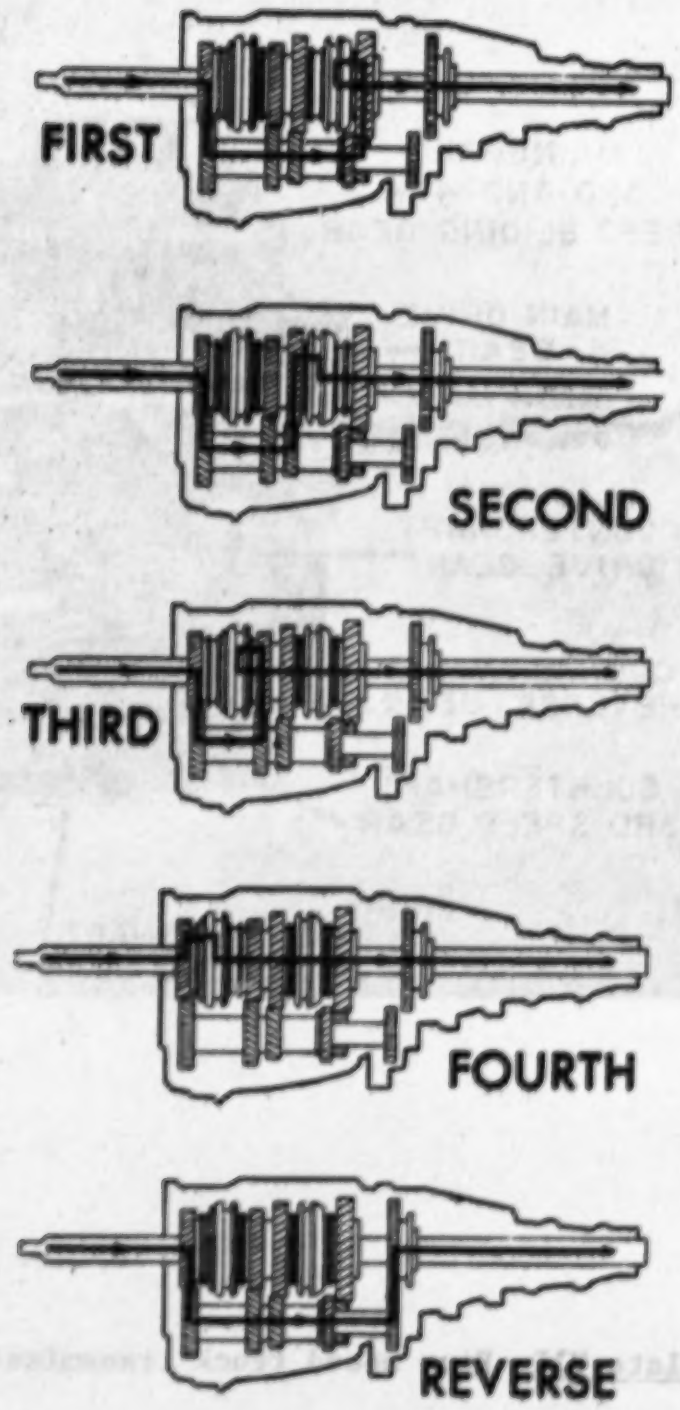



**Plate VIII** Four speed constant mesh transmission

AM 2-2D
1/18/67

# UNDERSTANDING MECHANICAL TRANSMISSIONS

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A 1

Check to see that timer is OFF

1-1

1

This film lesson is designed to supplement text AM 2-2, Mechanical Transmissions, by reviewing the important points of the text. There will be some questions in this film on the subject of mechanical transmissions. Read carefully and think before answering.

Press A 2

1-2

2

The purpose of a transmission is to_____

_____.

5 A. provide a means of regulating the ratio between engine speed and rear wheel speed

3 B. prevent driver fatigue from shifting due to various driving conditions encountered

4 C. provide a means of reducing engine speed over rear wheel speed

1-3

3

No. We haven't discussed automatic or semi-automatic transmissions yet. With a mechanical transmission there is bound to be a lot of shifting by the operator, for this is unavoidable. Try this question again.

Press A 2

1-4

4

No. It is the other way around: a transmission allows high engine speed with slow rear wheel turning. For instance: in low gear, the ratio is the greatest; there may be a 12:1 ratio (or greater) differential from engine to wheels. This means the crankshaft is turning 12 times to every one revolution of the rear axle.

Press A 5

1-5

5

Right. Not only does the gear ratio change when down-shifting a transmission, but the torque also changes. Torque is measured in (1) and (2) when there is a speed reduction. (Choose one of the following A, B or C):

6 A. (1) foot-increments (2) decreases

7 B. (1) pound-feet (2) increases

6 C. (1) foot-pounds (2) increases

1-6

6

No. You are incorrect. Torque is measured in pound-feet, and it increases in a transmission as down-shifting takes place. Remember that in gear systems, speed reduction means torque increase.

Press A 7

1-7

7

OK. Let's talk about measuring torque.

Torque on shafts or gears is measured as a straight-line force at a distance from the center of the shaft or gear. For instance, suppose we want to measure the torque in the gears shown in Plate I. And suppose, with some type of a measuring instrument, we found that the tooth of the driving gear (see Plate II) is pushing against the tooth of the driven gear with a 25 pound force.

Press A 8

1-8

8

This force, at a distance of one foot (the radius or distance from the center of the driving gear), means a torque of 25 lb. ft. That is, the smaller, driving, gear is delivering a torque of 25 lb. ft.

The 25 pound push from the gear teeth of the smaller gear is applied to the gear teeth of the larger gear. But it is applied at a distance of two feet from the center. Look at Plate II. We can see that the drive gear has 24 teeth, and the driving gear has 12. This would make the torque on the larger gear shaft____ lb. ft.

8 A. 12.5
9 B. 25
10 C. 50

1-9

9

No. You are incorrect. The torque in the larger gear is 50 lb. ft. (25 x 2). The same force is acting on the teeth of the larger gear, but it is acting at twice the distance from the shaft center.

Press A 10

1-10

10

That is correct. The gear ratio in this case is 2:1, but the torque ratio if 1:2. The larger gear turns at half the speed of the smaller gear; but the larger gear has twice the torque.

If a 12 tooth gear is meshed with a 36 tooth gear, the (1) tooth gear will turn (2) time(s) to every (3) time(s) the (4) tooth gear turns.

11 A. (1) 36 (2) 1 (3) 1 (4) 12
11 B. (1) 12 (2) 3 (3) 3 (4) 36
12 C. Neither A or B is correct.

1-11

11

No. The 12 tooth gear turns 3 times to every 1 time the 36 tooth gear turns, or a 3:1 ratio. Of course, if the smaller gear is the driving gear, the torque ratio is 1:3. (3 times as much on the larger gear as on the small.)

Press A 12

1-12

12

Correct.

Suppose we had an engine in a vehicle delivering 500 lb. of torque. The gear reduction (in low gear) from engine to rear wheels is 16:1. The torque on each rear wheel (each wheel is 4 ft. in diameter) of a four wheel bogie (ignoring friction losses) would be_____pounds of torque.

13 A. 8000
13 B. 16000
14 C. 4000

1-13

13

No. You are incorrect. We have a 16:1 gear reduction, with a 500 lb. torque from the engine. 500 x 16 = 8000.

However, the wheels (4) are four feet in diameter (or two feet from axle to ground). This would be 2 x 8000, or 16000 lb. of torque being applied to the bogie.

Since there are 4 wheels, each wheel has a forward push or torque of 4000 lb.

1-14

Press A 14

14

Correct. With this ratio (16:1) there would be a 4000 lb. forward push or torque for each wheel of the four wheel bogie.

GEARING PRINCIPLES -- To understand how and why transmissions function, it is necessary to understand gears and what they can be made to do. Let's review some of the basic principles we learned about gearing from previous units or films, when engine gear trains were discussed.

2-1

Press A 16
XC 15

15

You have missed one or more of the questions in this sequence of material. Let's review the last few frames before going on to new material. Please read carefully, and think before answering the questions.

Press A 2

2-2

16

Gears can do three things: (1) change the direction of motion; (2) increase or decrease the speed of the applied motion; and (3) magnify or reduce the force which is applied.

One other characteristic of gearing is that no slippage is possible, as it is in belt driven arrangements. To see all of these characteristics, let's examine a simple machine like the egg-beater; see Plate III.

Press A 17 2-3

17

In Plate III, the crank handle is turned in the direction indicated by the arrow: clockwise, when looking from the right. There are 32 teeth on gear (A) that mesh with 8 teeth on gear (B).

This arrangement will_____.

18 A. decrease the speed of the applied motion
19 B. change direction of motion
18 C. magnify the force which is applied

2-4

18

No. You are incorrect. Look at Plate III again. The crank handle is on a horizontal plane, and the shaft connected to the 8 tooth gear is on a vertical plane.

Think what has been accomplished here and try this question again.

Press A 17 2-5

19

Correct. The handle lies on a horizontal plane, and the 8 gear tooth shaft is vertical. What has been accomplished here is a change in the direction of motion from (A) to (B).

In this gear arrangement, (see Plate III), for every complete revolution that (A) makes, (B) makes four, and since (C) has the same number of teeth as (B), (C) also revolves four times.

This arrangement will_____.

20 A. magnify the force applied
20 B. reduce the speed of the applied motion
21 C. Neither A or B is correct

2-6

20

No. You are incorrect. Think of the engine flywheel and the starter gear. This is the same situation, except that the force is applied from the small gear until the engine flywheel moves faster than the small gear; then the force is being applied from the flywheel.

Try this question again.

Press A 19 2-7

21

Correct. This is not a magnification of force, nor a drop in the speed of applied motion. It is an increase in speed of applied motion. Gears (B) and (C) turn four times as fast as gear (A), since there is a 1:4 ratio.

This means that_____force has been applied to (A) for the mechanical advantage involved here.

22 A. less
23 B. more

2-8

22

No. The answer is: more force has to be applied to (A) since the mechanical advantage is less than one. Remember, an increase in speed (as is true here) is accomplished at the expense of force.

Press A 23 2-9

23

Correct. The beater is the same as a third class lever, where in order to speed up the movement of an object, a larger amount of effort is required.

Changing direction with gears -- Let's review how reversing of a vehicle is accomplished through the transmission. We know it must be done by the transmission, since it's impossible to reverse rotation of the crankshaft.

Plate IV shows a very simple mechanical transmission in the reverse position. Let's examine it.

2-10

Press A 24

24

We learned when studying engine gear trains that to get two external gears to turn in the same direction, it is necessary to insert a third gear, called an idler, between them. Plate IV shows this type of an arrangement. In addition to providing a reverse for the vehicle, it _____ torque which is required in reverse position.

25 A. increases
25 B. reduces
28 C. Neither A or B is correct 2-11

25

No. You are incorrect. The idler gear does not affect the ratio between the countershaft reverse gear and the low and reverse gear. It only provides a link between the two, and enables the gears to turn in the same direction.

Press A 26 2-12

26

Correct. The idler gear neither reduces nor increases torque in this situation. It is only a means of transmitting the action from the lower gear to the upper one.

The torque increase is gained in this position, see Plate IV, by the fact that the transmission drive gear is smaller than the countershaft drive gear. This is a _____ statement.

27 A. true
27 B. false
28 C. partially true 2-13

27

No. Partially true is the correct answer. The torque is multiplied by the fact that the clutch shaft gear is smaller than the countershaft drive gear, but it is also multiplied (again) because the countershaft reverse gear is smaller than the low and reverse gear.

Press A 28 2-14

28

Correct. Torque is multiplied twice in this illustration. Reverse gear in a transmission of this type usually is a torque ratio of 9:1 (approximate).

Changing speed with gears -- as we have seen with the egg-beater, gears can be used to change speeds. Let's look at another example where gears are utilized in a little different manner but where the same principle is involved.

2-15

Press A 29

29

In any watch or clock, the mainspring (source of power) slowly unwinds and causes the hour hand to make one revolution in 12 hours. Through a series-or train-of gears, the minute hand makes one revolution each hour, while the second hand makes one each minute.

In Plate V, wheel(A) is the driver which has 10 teeth that mesh with wheel (B) having 40 teeth. How many times does wheel (A) have to rotate for wheel (B) to make one revolution? 2-16

30 A. 10 times
31 B. 4 times
30 C. 40 times

30

No. Remember when the ratio is 1:4 (as in this case 10 teeth to 40 teeth), the small gear makes four revolutions as the large gear makes one.

The torque on the large gear shaft would be greater than the small gear. This is a _____ statement.

31 A. true
~~4~~ B. false

To advance the film, you must select the correct answer. 2-17

31

Correct. This would be a 1:4 ratio between gears. Wheel (C) is rigidly fixed on the same shaft with (B). Thus (C) makes the same number of revolutions as (B). However, (C) has 20 teeth and meshes with wheel (D) which has only 10 teeth. Hence, wheel (D) turns twice as fast as wheel (C).

Make sure you picture this in your mind before moving to the next frame. 2-18

Press B 32

32

If gear (A) is turning at a speed of four revolutions per second, we know that gear (B) will make one revolution every second.

However, what about gears (C) and (D)? Gear (C) will make (1) revolution(s) per second, while gear (D) makes (2) revolutions per second.

33 A. (1) one (2) four
33 B. (1) two (2) four
34 C. (1) one (2) two

2-19

33

No. Look at Plate V closely. Gear (B) is making one revolution. Also remember that gear (C) is attached to gear (B). However, gear (C) has twice the teeth that gear (D) has.

Try this question again.

Press A 32

2-20

34

Correct. Gear (C) is attached to gear (B), which is making one revolution per second. However, gear (C) has 20 teeth while gear (D) has 10, making a 1:2 ratio. So, if gear (C) is turning once every second, then (D) is turning 2 times. Let's examine what's taking place here. Gear (A) is turning 4 times to every 2 times gear (D) is turning.

Thus the overall speed reduction is 2/4 or 1/2, which means we get half the speed out of the last gear that was put into the first gear.

2-21

Press A 35

35

Any gear speed-reduction problem, such as the one just discussed, can be solved by using this formula:

$$S_2 = S_1 \times \frac{T_1}{T_2}, \text{ where}$$

$S_1$ = speed of first shaft in train

$S_2$ = speed of last shaft in train

$T_1$ = product of teeth on all drivers

$T_2$ = product of teeth on all driven gears

Now let's prove this formula by solving the gear problem mentioned earlier.

2-22

Press A 36

36

Substituting numbers for the symbols in the formula

$$S_2 = S_1 \times \frac{T_1}{T_2}$$

we have:

$$S_2 = 4 \times \frac{10 \times 20}{40 \times 10} = \frac{800}{400} = 2$$

or: 2 revolutions per second.

Copy this formula for future use.

Press A 36.1

2-23

36.1

Almost any increase or decrease in speed can be obtained by choosing the correct gears for the job.

Look at Plate V again. If we placed an idler gear between gear (A) and (B), gear (D) would be rotating _____.

37 A. at half the speed it was without the idler gear
38 B. in a different direction than before
37 C. Neither A or B is correct.

2-24

37

No. The ratio would be the same: gear (D) would still be turning at 2 revolutions per second. The difference here is that gear (D) would be turning in the opposite direction than it was before. The only gear in this train that wouldn't be turning in a different direction is gear (A).

Press A 38

2-25

38

Correct. The insertion of idler gears does not change the ratio between the gears, only the direction of rotation.

Magnifying force with gears -- As we have learned in the past, with a reduction in speed, there is a comparable increase in torque. In other words, the effect of the effort which is administered is multiplied.

Let's look at the simple winch in Plate VI. The crank arm is 30 inches long, and the drum on which the cable is wound has a 15 inch radius.

3-1

Press A 40
XC-39

39

Gear (D) would be turning in a different direction.

You have answered one or more of the questions in this sequence of material incorrectly. Let's review this portion once more. Read carefully and take your time in answering the questions.

Press A 16

3-2

40

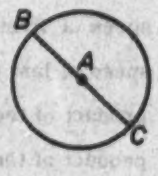
The diameter of the drum in Plate VI would be _____ the length of the crankarm.

41 A. greater than
42 B. the same as
41 C. less than

3-3

41

No. If the drum has a radius of 15", it would have the same diameter (30") as the length of the handle. Radius of a circle refers to a straight line from the circle center to the outer perimeter, or in this picture from (A) to (B). Diameter is from (B) to (C).

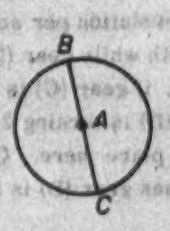



3-4

Press A 42

42

Correct. Radius of a circle is from the circle center point to the outer perimeter, as shown in the picture from (A) to (B). Diameter of the circle is from (C) to (B).




The small pinion gear has 10 teeth, which mesh with the 60 teeth on the internal spur gear. Let's figure out (approximately) what the mechanical advantage of this winch would be. Think of this mechanism as two machines in one.

3-5

Press A 43

43

First, let's figure what the gear and pinion does for us. The theoretical mechanical advantage of any arrangement of two meshed gears can be found by the following formula:

$$MA = \frac{T_o}{T_a}$$

where: MA = mechanical advantage (theoretical)
$T_o$ = number of teeth on driven gear, and
$T_a$ = number of teeth on driver gear

Copy this formula, then Press B. 43.1

3-6

43.1

In this situation $T_o = 60$ and $T_a = 10$, or:

$$MA = \frac{60}{10} = 6$$

Examine this carefully before moving on to the next frame.

Press A 44

3-7

44

Suppose we reverse the problem just discussed, and make the driven gear (drum) the driver, and the driver gear, (10 tooth), the driven gear. The formula would look like this:

$$MA = \frac{10}{60} = .6$$

When MA is .6 or less, or less than one, _____.

45 A. the force required to move the drum would decrease
46 B. the small gear would turn much faster
47 C. the winch would be useless

3-8

45

No. The force required to move the drum would be much greater, due to the mechanical advantage being less than one, or .6. Under these circumstances, the winch would be useless as a machine.

Press A 47

3-9

46

The small gear would turn much faster (if the drum could be turned), but with the mechanical advantage being less than one (.6), turning of the drum would be practically impossible. In other words, the winch would be pretty useless as a machine.

Press A 47

3-10

47

All right. With the mechanical advantage being reversed, or .6 instead of 6, the winch would be useless as a machine.

Now, let's look at the other part of the machine, which is a simple wheel-and-axle arrangement consisting of the crank arm and drum. The mechanical advantage of this can be found by dividing the distance the effort moves. To understand how this is figured, let's review a little basic geometry about circles.

Press A 48

3-11

48

A circle is a curved line on which every point is equally distant from a point within, called the center. The radius is any line drawn from the center to the outer edge. The diameter is twice the radius. The circumference is the complete distance around the circle.

Pi, written π, is a constant used in computing the circumference of a circle.

Press A 49

3-12

49

The quantity π is a constant approximately equal to 3 1/7, or 3.1416. If you measure the circumference of any circle and divide by the diameter, the answer will always be 3.1416.

The formula for this is:

$$\pi = \frac{c}{d} \quad \text{or} \quad \pi = \frac{c}{2r}$$

where: c = circumference
d = diameter
r = radius

Press A 49.1

3-13

49.1

Since π is constant (3.1416) we can also get the circumference by using this formula:

$$c = \pi d = 3.1416 \times d$$

or $c = 2\pi r = 2 \times 3.1416 \times r$

Write this formula down before pressing A.

(If you would like another look at the frame before this,
Press C) 50

3-14

50

Let's take an example of how the circumference of a wheel is found if you know the length of one spoke. If the spoke of this wheel is 21 inches, its circumference is_____.

51 A. 264 inches
52 B. 132 inches
51 C. Don't know

3-15

51

No. The correct answer is: 132 inches.

We said the spoke is 21 inches: this is the radius. Use the formula:

$c = 2\pi r$

$c = 2 \times 3\ 1/7 \times 21$

$c = 2 \times \frac{22}{7_1} \times 21^{3}$

$c = 2 \times \frac{22}{7_1} \times 21_{3} = 132$ inches

Press A 52

3-16

52

Correct. The length of the spoke in this wheel represents the radius. From this we can find the circumference by using the formula: $c = 2\pi r$.

Let's try one more problem. The circumference of a pulley is 33 inches. Its diameter is_____.

54 A. 10 1/2 inches
53 B. 12 1/2 inches
53 C. Don't know

3-17

53

No. The correct answer is 10 1/2.

We said the circumference of the pulley is 33 inches.
Use the formula:

$$\pi = \frac{c}{d}$$

$$\frac{22}{7} = \frac{33}{d}$$

By cross-multiplying, we get:

$$22d = 231$$
$$d = 10.5$$

3-18

Press A 54

54

Correct. The diameter measures 10 1/2". This answer was obtained by using formula $\pi = \frac{c}{d}$.

Now let's get back to determining the mechanical advantage of the other part of the winch. Remember, the other part was a simple wheel-and-axle arrangement consisting of the crank arm and drum. The MA of this is determined by dividing the distance the effort moves ($2\pi R$) in making one complete revolution by the distance the cable is drawn up in one revolution of the drum ($2\pi r$).

3-19

Press A 55

55

In other words, the large R represents the crank arm length (30") and the small r represents the drum's radius (15"). With this we have a formula:

$$MA = \frac{2\pi R}{2\pi r} = \frac{R}{r} = \frac{30}{15} = 2$$

In a compound machine such as this, where there are two machines in one, the total MA is found by multiplying the separate MA's together. Here we determined an MA of 6 and an MA of 2. Multiplying, we have 6 x 2 or 12. This represents the overall MA of the winch.

3-20

Press A 56

56

We have determined that the MA of this winch is 12. However, since friction is present, the actual mechanical advantage may only be 7 or 8. Even so, by applying a force of 100 pounds on the handle, it is possible to lift a load of 700 or 800 pounds.

There may be some questions in your mind what all this has to do with transmissions. The point is: magnification of effort through gearing.

3-21

Press A 57

57

For instance, look at Plate V once again. We determined earlier that gear (D) was turning half the speed of gear (A). To determine the mechanical advantage of this gear arrangement, we would first _____

_____

58 A. find the number of revolutions per second each gear is turning

60 B. distinguish the driven gears from the driver gears

59 C. find how many teeth each gear has

3-22

58

No. The number of revolutions per second would have nothing to do with determining the mechanical advantage of these gears. The MA is a constant factor, no matter what the speed is. Try this question again and think of how we determined the MA of the winch.

3-23

Press A 57

59

No. The number of teeth each gear has is definitely a factor here and is necessary for figuring the MA.

However, this information is useless if we do not know which are the driver gears and which are the driven gears.

3-24

Press A 60

60

Correct. First, we must determine which of these gears are the drivers and which are being driven.

For calculating mechanical advantage it is also necessary to know the number of teeth on each gear. In figuring MA for the gearing arrangement in Plate V, the formula _____ would be used.

61 A. $S_2 = S_1 \times \frac{T_1}{T_2}$ 62 C. $MA = \frac{2\pi R}{2\pi r}$

63 B. $MA = \frac{T_o}{T_a}$

3-25

61

No. This formula is used to determine revolutions of gears when one is of a larger diameter than the other. The formula to use here is: MA = $\frac{T_o}{T_a}$.

Press A 63

3-26

62

No. This formula would not fit here. Remember, this was used to determine the MA for the crank handle and cable movement on the winch. The formula to use for figuring MA of the gearing in Plate V is MA = $\frac{T_o}{T_a}$.

Press A 63

3-27

63

That is correct. Driver gear (A) has 10 teeth while the driven gear (B) has 40. Applying the formula, we get:

$$MA = \frac{T_o}{T_a} = \frac{40}{10} = 4$$

The mechanical advantage of 4 is only part of the answer in this train of gears. Remember, in the winch we had two machines in one. The same is true here.

On a piece of scratch paper, figure the other MA. Your answer for the MA between (C) and (D) gears should be _____.

64 A. 2
65 B. 1/2
64 C. 4

3-28

64

No. Using the formula, MA = $\frac{T_o}{T_a}$, we substitute the number of teeth in gear D for $T_o$ because D is being driven, and the number of teeth for gear C which is the driver:

$$MA = \frac{10}{20} = 1/2$$

Press A 65

3-29

65

Correct. Now, to get the overall mechanical advantage of this arrangement, the two figures obtained are _____.

64 A. added
67 B. multiplied
XC - 66

(The correct answer must be selected before moving to the next frame).

3-30

66

The correct answer to the last problem is 1/2.

You have answered one or more of the questions in this sequence of material incorrectly. Review the last few frames, read them carefully, and take your time in answering the questions.

Press A 38

3-31

67

OK. The two must be multiplied together. The first MA was 4, the second was 1/2. Multiplying them together we get 4 x 1/2 or an overall MA of 2.

We can see now that, with different combinations of gears in a transmission, it is possible to change a vehicle's speed while the engine speed remains the same. It is all a matter of gear ratios, having large gears drive small gears and small gears drive large gears.

4-1

Press A 68

68

In a four-speed truck transmission, such as shown in Plate VII, when the operator shifts from neutral to first gear _____.

69 A. both shafts (countershaft and main shaft)slide forward

70 B. the countershaft drive gear is engaged with the main drive gear

71 C. the smallest countershaft gear is engaged

4-2

69

No. You are incorrect. Both shafts in this transmission do not slide; only the top or main shaft slides forward and backward.

Try this question again. Think how much torque is required in low gear.

Press A 68

4-3

70

No. The countershaft drive gear is engaged whenever the transmission is in gear (except neutral). The answer we want here is that the smallest gear on the countershaft is engaged.

Press A 71

4-4

71

Correct. To get the most torque from this transmission for low gear position, the smallest gear on the countershaft has to be engaged with the_____gear on the main shaft. This relationship gives us the multiplication that is required.

72 A. smallest
72 B. medium
73 C. largest

4-5

72

No. To get the greatest amount of torque from this transmission, the small drive gear on the main shaft meshes with the large drive gear on the countershaft. This is one multiplication. The second multiplication of torque is in meshing the low speed gear on the countershaft with the largest gear on the main shaft.

Press A 73

4-6

73

Correct. By meshing the low speed gear with the largest gear on the main shaft, we get one multiplication of torque. The other multiplication comes from meshing the main drive gear with the countershaft drive gear.

In the low position, the (1) gears are being driven by the (2) gears.

75 A. (1) large (2) small
74 B. (1) small (2) large

4-7

74

No. The two driving gears are the small ones, the main drive gear and the countershaft low speed gear. The large ones are being driven.

Press A 75

4-8

75

Correct. The large gears are being driven. When this transmission (Plate VIII) is in low gear, there is a 7 to 1 ratio. This means the engine shaft is turning 7 times to every 1 the propeller shaft is turning. This is when maximum power can be obtained. In high gear or 4th gear, the ratio is 1 to 1 or the engine shaft is turning at the same speed as the propeller shaft. The gear ratio in second is 3.48 to 1, and in third is 1.71 to 1.

4-9

Press A 76

76

Constant mesh transmissions differ from the standard transmission (just discussed) in that_____.

77 A. herringbone gears are used in place of spur gears
77 B. some of the main shaft gears are in constant mesh with the countershaft gears
78 C. all gears on the main shaft are in constant mesh with the countershaft gears

4-10

77

No. Helical gears are used in place of spur gears for reduced noise.

The correct answer is that some of the gears on the main shaft are in constant mesh with the gears on the countershaft.

Press A 79

b-11

78

No. Some transmissions have more gears in constant mesh than other transmissions, but never do they have all gears in constant mesh, especially the reverse gear!

Press A 79

b-12

79

Correct. The constant mesh of these countershaft gears and main shaft gears is done by_____

_____.

80 A. using external and internal teeth type bearings

82 B. mounting the main shaft gears on roller bearings

81 C. mounting the countershaft gears on roller bearings

b-13

80

No. B is true that these type gears are used in constant mesh type transmissions, but this would not allow the gears to be in constant mesh during operation.

The correct answer is that the mainshaft gears (constant mesh) are mounted on roller bearings which allow them to revolve about the shaft.

Press A 82

b-14

81

No. The main shaft gears (constant mesh) are the ones mounted on roller bearings. The gears on the counter shaft are splined to the shaft.

Press A 82

b-15

82

Correct. Plate VIII shows a four-speed transmission with all forward gears in constant mesh. This transmission has two synchronizing clutch assemblies. The synchronizing devices permit gears to be selected without clashing, by synchronizing the speeds of the mating parts before they mesh.

Press A 83

b-16

83

Congratulations, you have completed this film AM 3-2D on Mechanical Transmissions.

Press REWIND

XC - 84

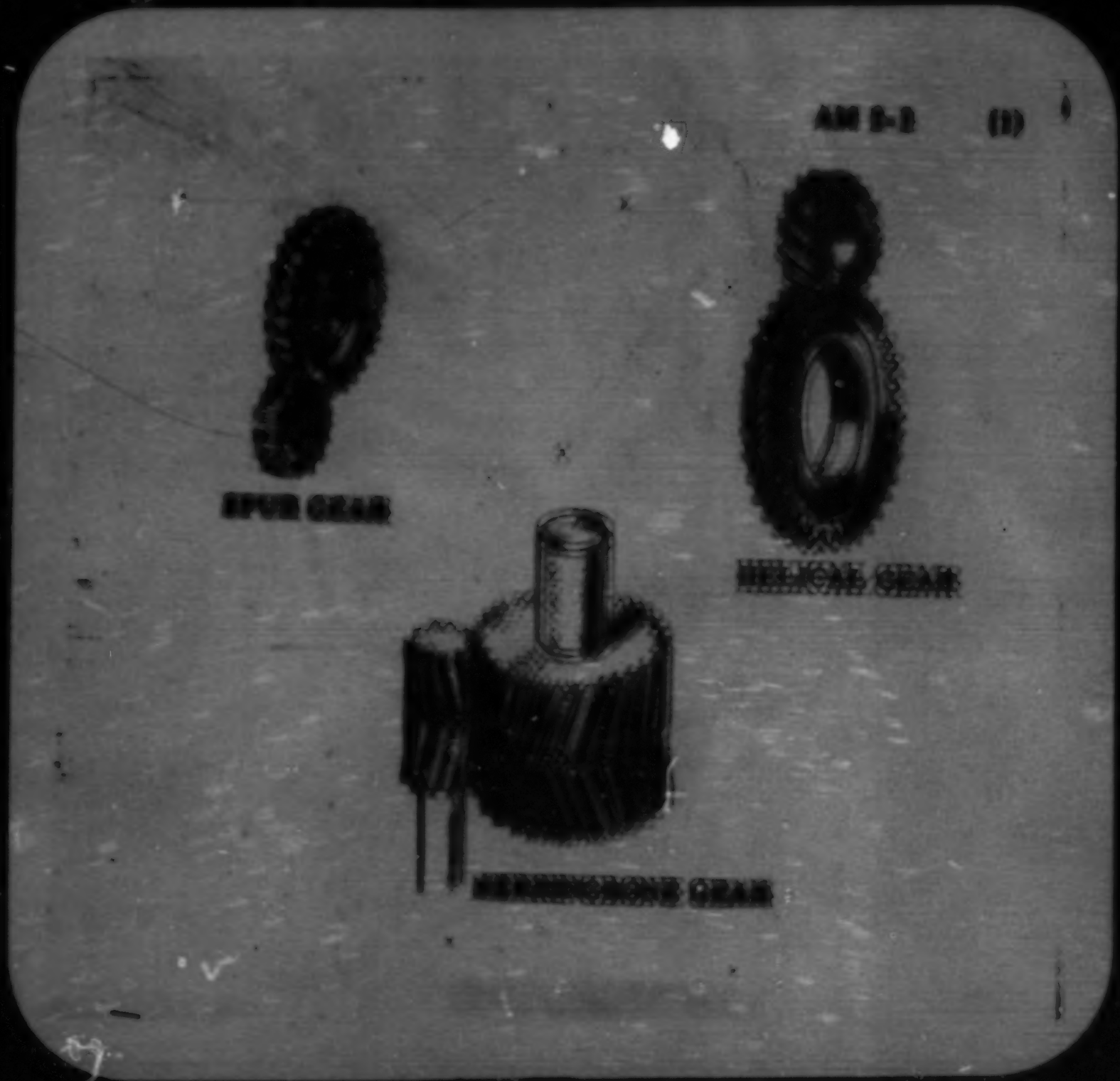
b-17

84

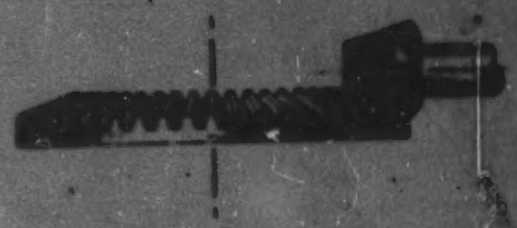
You have missed one or more of the questions in this last sequence of material. Review this last part again. Read carefully and take your time in answering the questions.

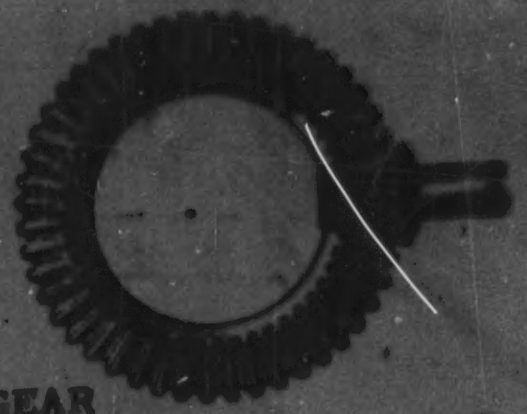
Press A 68

b-18

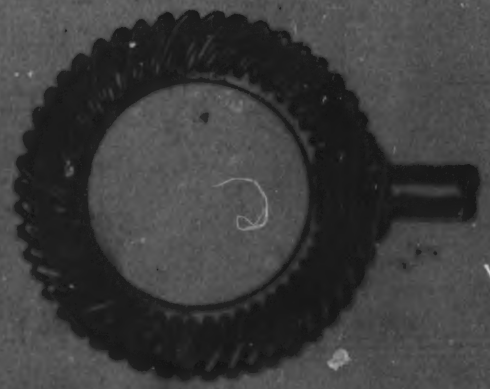

SPUR GEAR
HELICAL GEAR
HERRINGBONE GEAR

AM 2-2

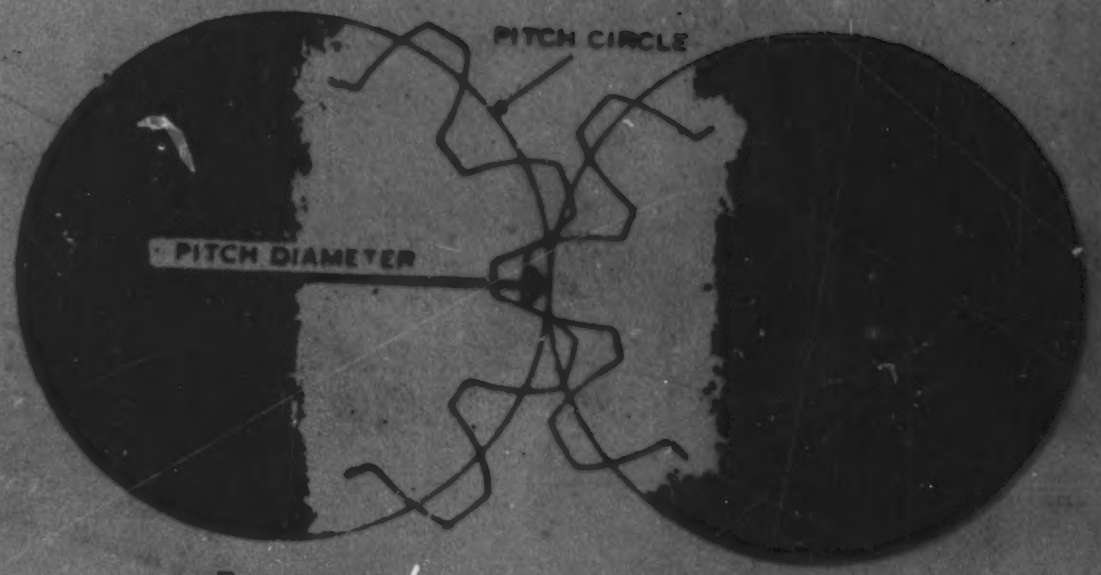




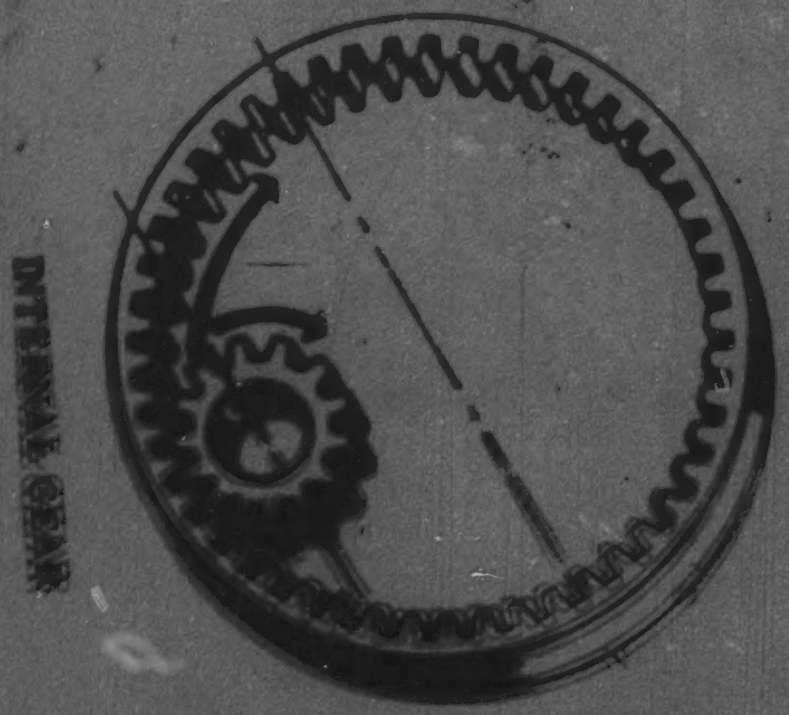
SPUR BEVEL GEAR

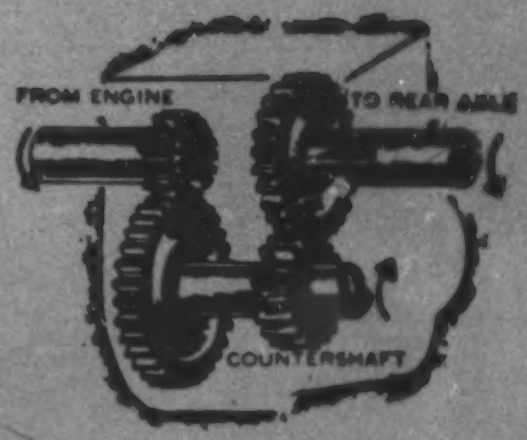


SPIRAL BEVEL GEAR

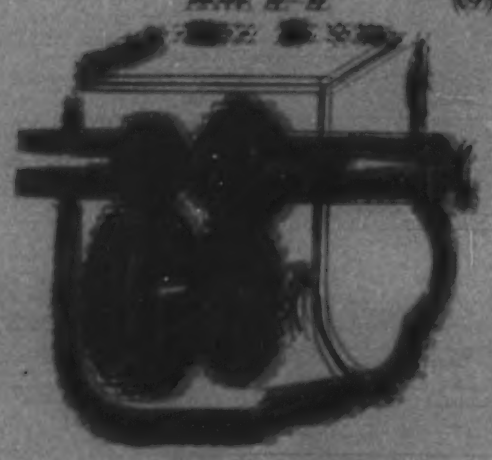



PITCH DIAMETER

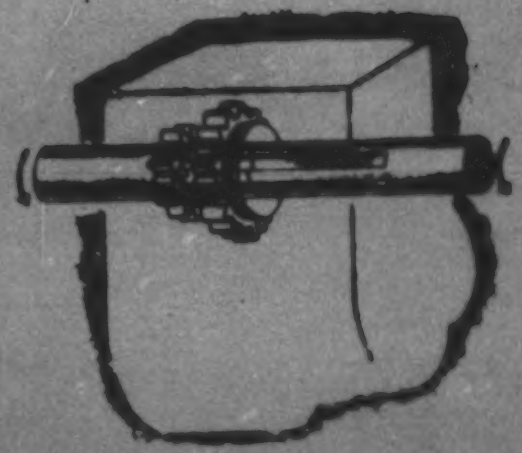

INTERNAL GEAR




FIRST OR LOW GEAR



SECOND OR INTERMEDIATE GEAR



THIRD OR HIGH GEAR

REVERSE GEAR

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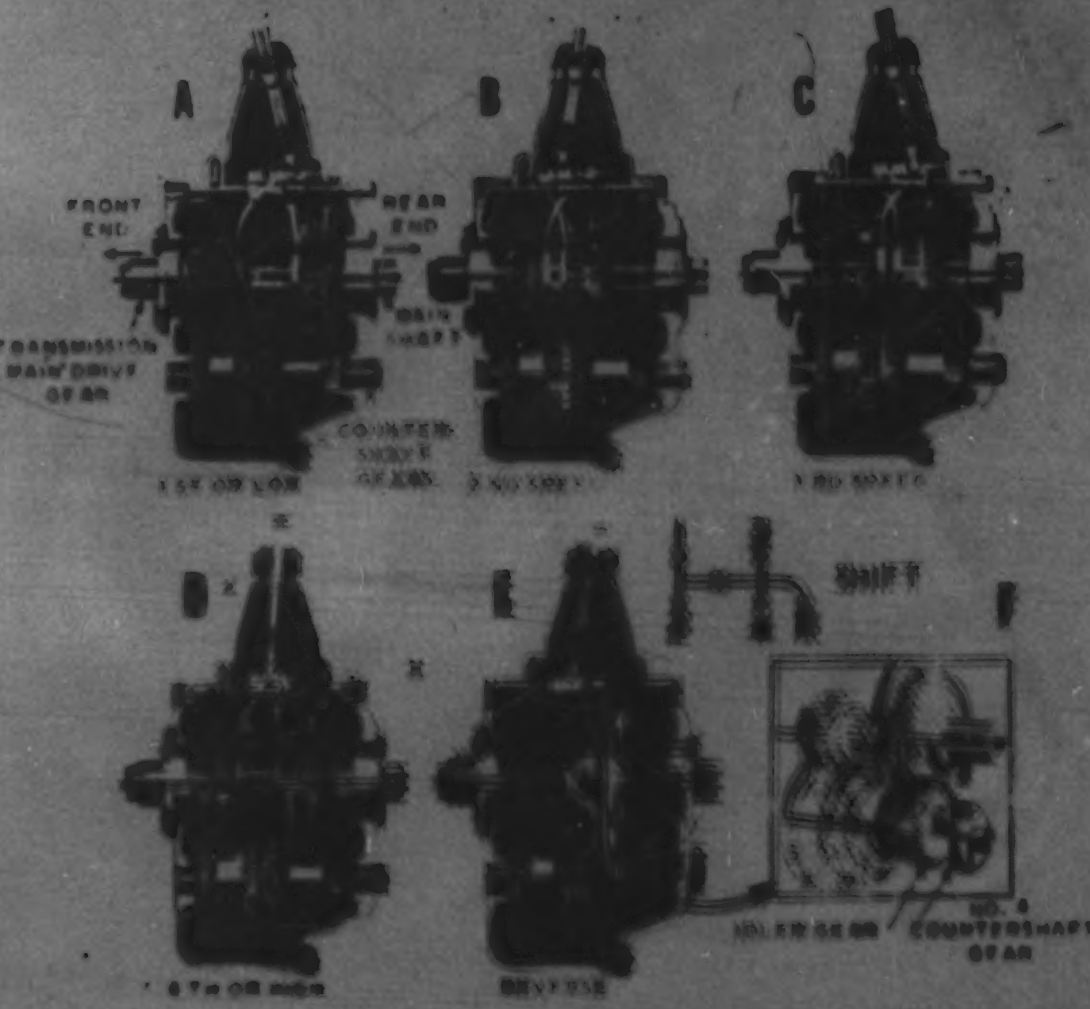


**POWER FLOW THROUGH A FOUR-SPEED TRANSMISSION**

HUMAN ENGINEERING INSTITUTE
2341 Carnegie Ave
Cleveland, Ohio 44115

EXECUTIVE DEVELOPMENT • SUPERVISORY TRAINING • TRAINING OF KEY PRODUCTION AND MAINTENANCE EMPLOYEES
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## INSTRUCTOR'S GUIDE

Title of Unit: MECHANICAL TRANSMISSIONS

AM 2-2
3/7/67

FIRST: Be sure all questions have been answered that students might have on home study units or Didactor films.

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OBJECTIVES:

1. To introduce to the students the simplest of transmissions: the mechanical or manually operated type.
2. To show why and how the various speed ratios are obtained, by discussing types and arrangements of gears.
3. Make the student aware of some troubleshooting tips he can use when working with transmissions.

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LEARNING AIDS suggested:

VU-CELLS:

| | |
|---|---|
| AM 2-2 (1) | Spur gear<br>Helical gear<br>Spur bevel gear |
| AM 2-2 (2) | Spiral bevel gear<br>Herringbone gear |
| AM 2-2 (3) | Pitch diameter |
| AM 2-2 (4) | Internal gear |
| AM 2-2 (5) | First or low gear<br>Second or intermediate gear<br>Third or high gear<br>Reverse gear |
| AM 2-2 (6) | Power flow through a four-speed transmission |

MODELS:

Any components of a mechanical transmission that can easily be brought to class will help in explaining and demonstrating the subject.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. What function does the transmission serve?
2. When would a great amount of ratio differential be required on some vehicles and not so much on others?

3. Where is the transmission located?
4. How does a helical gear differ from a spur gear?
5. What is meant by pitch diameter and pitch circle?
6. In a gear arrangement having a small gear with 12 teeth and a large gear having 24 teeth, how many times does the small gear turn when the large gear makes one revolution?
7. In the situation (question 6 above), how does this affect torque?
8. In what gear is there a one-to-one ratio?
9. Can any combination of gears actually change engine power? Why or why not? How is power to the drive wheels controlled or changed?
10. Where are idler gears used other than in a transmission? What is their purpose? Do they change speed or torque?
11. What is meant by a constant mesh transmission?